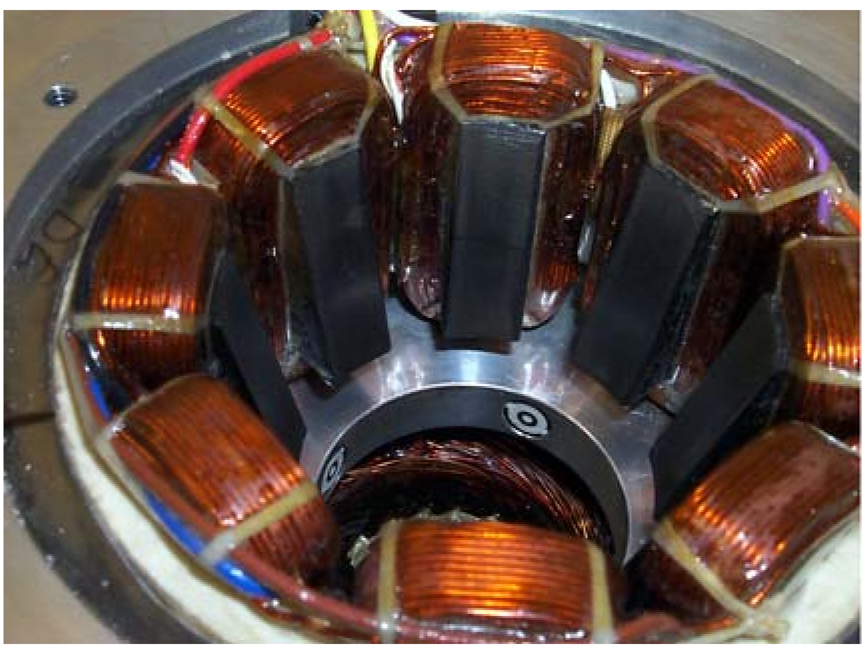
Conical Magnetic Bearings Developed for Active Stall Control in Gas Turbine Engines

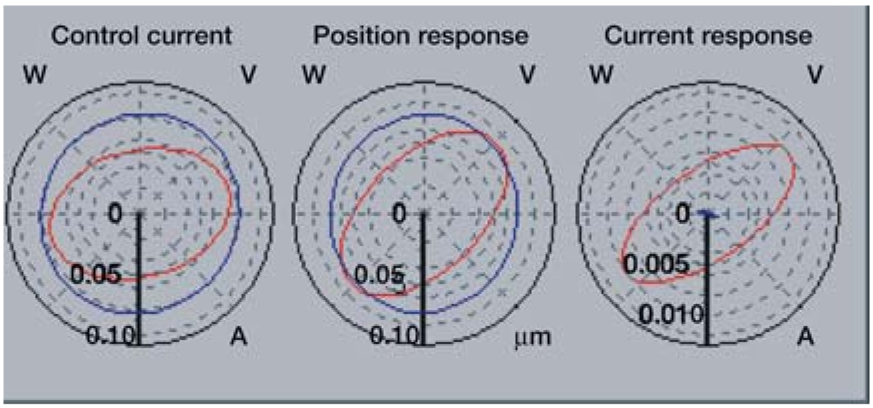
Active stall control is a current research area at the NASA Glenn Research Center that offers a great benefit in specific fuel consumption by allowing the gas turbine to operate beyond the onset of stall. Magnetic bearings are being investigated as a new method to perform active stall control. This enabling global aviation safety technology would result in improved fuel efficiency and decreased carbon dioxide emissions, as well as improve safety and reliability by eliminating oil-related delays and failures of engine components, which account for 40 percent of the commercial aircraft departure delays.

Active stall control works by perturbing the flow in front of the compressor stage such that it cancels the pressure wave, which causes the compressor to go into stall. Radial magnetic bearings are able to whirl the shaft so that variations in blade tip leakage would flow upstream causing a perturbation wave that could cancel the rotating stall cell. Axial or thrust magnetic bearings cannot be used to cancel the surge mode in the compressor because they have a very low bandwidth and thus cannot modulate at a high enough frequency. Frequency response is limited because the thrust runner cannot be laminated. To improve the bandwidth of magnetic thrust bearings, researchers must use laminations to suppress the eddy currents. A conical magnetic bearing can be laminated, resulting in increased bandwidth in the axial direction. In addition, this design can produce both radial and thrust force in a single bearing, simplifying the installation.



Conical magnetic bearing stator.

The proposed solution combines the radial and thrust bearing into one design that can be laminated--a conical magnetic bearing. The new conical magnetic bearing test rig, funded by a Glenn fiscal year 2002 Director's Discretionary Fund, was needed because none of the existing rigs has an axial degree of freedom. The rotor bearing configuration will simulate that of the main shaft on a gas turbine engine. One conical magnetic bearing replaces the ball bearing in front of the compressor, and the second replaces the roller bearing behind the burner. The rig was made operational to 10,000 rpm under Smart Efficient Components funding, and both position and current adaptive vibration control have been demonstrated. Upon program completion, recommendations will be made as to the efficacy of the conical magnetic bearing for active stall control.



Filtered position and current response under current control. (V and W represent four of the five axes of control.)

Glenn contact: Jeffrey J. Trudell, 216-433-5303, Jeffrey.J.Trudell@nasa.gov
U.S. Army Research Laboratory, Vehicle Technology Directorate at Glenn contact: Albert F. Kascak, 216-433-6024, Albert.F.Kascak@grc.nasa.gov
Authors: Jeffrey J. Trudell, Albert F. Kascak, Andrew J. Provenza, and Carl J. Buccieri
Headquarters program office: OA
Programs/Projects: DDF, SEC, Flywheel Technologies